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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION of: CHEN ET AL.
Application No.: 09/822,831
Filed: April 2, 2001

Confirmation Number: 8466
Group Art Unit: 1746
Examiner: Crepeau, Jonathan

Title: CONDUCTING POLYMER-CARBON NANOTUBE COMPOSITE MATERIALS AND THEIR USES

REQUEST FOR RECONSIDERATION

Commissioner for Patents
P.O.Box 1450
Alexandria,VA 22313-1450

Sir:

In reply to the Office Action mailed March 11, 2004, please reconsider the patentability of the pending claims based on the following remarks. Claims 1-16 remain withdrawn from consideration as being drawn to a non-elected invention. Claims 17-24 and 26 are pending and subject to patentability consideration at this time.

Applicants submit that the photographs submitted herewith were obtained by electron microscopy, which produces black and white images; thus, it is not possible to submit corresponding colored images.

As a preliminary matter, the Office Action requested an explanation of the white dots in the electron microscope images. Such white dots are of no significance to the issues at hand but are likely to be a result of the surface texture of the polymer. A phenomenon of electron microscopy is that very small surface features can give rise to high-contrast white spots because the electrons are able to escape these small, high surface area features more readily, leading to strong detection (i.e., white appearance) in these regions.

Claims 17-24 and 26 remain rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent 6,205,016 to Niu. Applicants traverse the rejection because Niu fails to teach or suggest all the features recited in the rejected claims.

For example, as explained previously, Niu fails to teach or suggest an electronically conducting polymer/carbon nanotube composite produced by preparing a dispersion of carbon nanotubes in a solution of one or more polymerisable monomers which upon polymerisation form an electronically conducting polymer; and polymerising the monomer solution to form a unitary polymer mass containing discrete nanotubes individually coated in the electronically conducting polymer," as recited in independent claim 17.

Similarly, Niu fails to teach or suggest an electrical energy storage device, comprising: a first electrode consisting of a first composite of carbon nanotubes and a first electronically conducting polymer and a first conducting member in contact with the first composite; a second electrode; and an electrolyte comprising mobile cations and anions, the electrolyte separating the first and second electrodes and being in contact with the first composite, wherein the first composite consists of a unitary polymer mass containing discrete carbon nanotubes individually coated in the electronically conducting polymer dispersed therein and is formed by preparing a dispersion of carbon nanotubes in a solution of one or more polymerisable monomers which upon polymerisation form an electronically conducting polymer and polymerising the monomer solution to form the unitary polymer mass, as recited in independent claim 18 and its dependent claims 19-24.

Further, Niu fails to teach or suggest an electrical energy storage device comprising: a first electrode comprising a first composite of carbon nanotubes and a first electronically conducting polymer, and a first conducting member in contact with the first composite; a second electrode comprising a second composite of carbon nanotubes and a second electronically conducting polymer, and a second conducting member in contact with the second composite; and an electrolyte comprising mobile cations and anions, the electrolyte separating the first and second electrodes and being in contact with the first composite, wherein each of the first and second composite consists of a unitary polymer mass containing carbon nanotubes individually coated in the electronically conducting polymer dispersed therein and is formed by preparing a dispersion of carbon nanotubes in a solution of one or more polymerisable monomers which upon polymerisation form an electronically conducting polymer; and polymerising the monomer solution to form a unitary polymer mass," as recited in independent claim 26.

In response to Applicants' previous arguments, the Office Action asserted that, when the weight ratio of nanotubes to electrically conductive polymer is low enough in the Niu method, each nanotube would be at least partially coated with polymer.

In response to this assertion, the inventors have carried out further experiments replicating the process of Niu in the laboratory and performed comparative experiments to compare between the method of the invention and that of Niu to highlight the differences between the product produced by the claimed method and the product produced by the method of Niu. In following the method of Niu, a high weight ratio of electrically conductive polymer to nanotubes (12.5:1; recognized by the Office Action as a relatively high weight ratio) was used to address the Office Action's assertion.

As a result, Applicants submit photographs indicating the structural differences resulting from the two significantly different methods. Figures 1-6 include photographs taken of the results of the two methods (the Niu method in Figures 1-4 and the claimed method in Figures 5-6) obtained by electron microscopy. Figures 1-4 are scanning electron microscope images of samples of polypyrrole/multi-walled carbon nanotube composite prepared by the method of Niu with polymer to nanotube ratios of 12.5:1 (Figures 1 and 2) and 1:1 (Figures 3 and 4). The Niu method involves filtering a mixture of polypyrrole and carbon nanotubes. The experimental protocol which was used was previously detailed in the Response filed on December 10, 2003.

Figures 5 and 6 are scanning electron microscope images of samples of polypyrrole/multi-walled carbon nanotube composite according to the claimed invention. The method of preparing these composites involves forming polypyrrole in the presence of carbon nanotubes.

Figures 1 to 4 illustrate that the polymer does not preferentially coat the nanotubes when using Niu's method. Rather, the polymer deposits haphazardly fill the pores. Neither of the two polymer to nanotube ratio experiments (12.5:1 and 1:1) using Niu's method provided any indication that these was any mechanism by which the polymer could be preferentially deposited on the nanotubes using the Niu method. Where nanotubes can be seen in the Niu method samples, they are uncoated, as indicated by their diameter of approximately 10 nm, which is that of an uncoated nanotube. Thus, Figures 1-4 clearly show that Niu's method does not produce discrete nanotubes coated with conducting polymer as required by the claims.

By contrast, samples according to the invention have nanotubes with diameters of 10 nm (Figure 5) and 45 nm (Figure 6); these nanotubes are coated by a relatively thick and continuous layer of polymer to form composite rods of much larger diameter.

Furthermore, a lack of porosity is evident in the samples made using the Niu method. Even when the ratio of polymer to nanotubes was as low as 1:1, Niu's technique produced no significant porosity. This is in contract to the three-dimensional porous network nanostructure of the composites made using the claimed invention. As can be seen in Figures 5 and 6, even for high polymer to nanotube ratios (18:1 and 142:1), composites according to the invention exhibit excellent porosity.

Lack of porosity is a fundamental limitation of the filtration process, since open pores are preferentially filled during filtration. The long filtration times of several days required to make composite films using Niu's method also reflect the fact that the pores are blocked, since films with a high degree of porosity have faster filtration times. This lack of porosity is a further difference between the composites produced by Niu's method and those of the claims.

Thus, the composites of the invention have a novel structure when compared with those prepared by the Niu method. The composites produced by the invention have a nanoporous composite structure in which the nanotubes are coated by a continuous layer of conducting polymer. The composites of Niu do not have a nanoporous composite structure, and the nanotubes are not coated by a continuous layer of conducting polymer.

Furthermore, without pores throughout the composite, electrolyte is unable to access the entire structure effectively and capacitance is consequently limited. For this reason, the capacitance of the claimed composites is much better than the capacitance of composites made using the Niu technique. The inventors have previously demonstrated this difference in capacitance.

Therefore, the Office Action's assertion that "the claimed product appears to be the same or similar to that of the prior art, although produced by a different process" is false. Applicants have fulfilled their burden of providing evidence establishing the unobvious difference between the claimed produce and the prior art product by the submission of two sets of experiment results evidencing the differences between the claimed product and that of Niu. Thus, the claimed subject matter has been proven to be patentable. Claims 17-24 and 26 are patentable.

In view of the differences between the products of Niu and of the present invention, the claims are novel over Niu. Accordingly, it is submitted that the claims are allowable over Niu and that the application is in condition for allowance. Should further issues require resolution prior to allowance, the Examiner is requested to contact the undersigned.

Please charge any fees associated with the submission of this paper to Deposit Account Number 033975. The Commissioner for Patents is also authorized to credit any over payments to the above-referenced Deposit Account.

Respectfully submitted,

PILLSBURY WINTHROP LLP

CHRISTINE H. MCCARTHY
Reg. No. 41844
Tel. No. (703) 905-2143
Fax No. (703)905-2500

Date: June 29, 2004
P.O. Box 10500
McLean, VA 22102
(703) 905-2000